METHOD FOR SWITCHING BETWEEN HIGH-SPEED PACKET DATA SERVICE OPTION AND NON-HIGH-SPEED CIRCUIT SWITCHED OR PACKET DATA SERVICE OPTIONS WITHOUT DISRUPTING USER DATA FLOW

FIELD

This invention relates to CDMA (code division multiple access) data communication.

BACKGROUND

Mobile communication systems in North America are making the transition from second generation (2G) non-high-speed systems based on the IS-95 (Telecommunication Industry Association (TIA) interim standard number 95) standard to third generation (3G) high-speed systems based on IS-2000 (TIA interim standard 2000). It is expected that, especially in the early days of IS-2000 deployment, operators may concentrate on providing IS-2000 coverage (and, consequently, high-speed packet data service) in their highest traffic areas, leaving largely IS-95-only coverage areas in their networks in which they are unable to provide the high-speed packet data service option. Effectively, their networks are expected to have non-contiguous pockets of high-speed packet data coverage. However, the high-speed packet data service option in IS-2000 does not support non-IS-2000 physical channels.

Mobile communication system operators would like to provide their mobile packet data users with seamless coverage throughout their network. However, because the high-speed packet data service option does not support the older non-high-speed IS-95 traffic channels, a user crossing the boundary of IS-2000 coverage will not be able to retain the high-speed packet data service option. Consequently, the

entire packet data session will be terminated or put on hold netting loss of service.

If the user wants to continue Internet access after moving from an IS-2000 coverage pocket to an IS-95 coverage pocket or a mixed IS-2000/IS-95 pocket where the IS-2000 service is congested, he/she would have to establish a new call manually. This can result in significant data loss. In many cases, the user's applications will not survive this interruption, and the users themselves will have to manually re-initialize or restart.

SUMMARY

This invention provides a method whereby the operator's network infrastructure can continue to offer the user data service outside the IS-2000 (3G) coverage area without requiring manual user intervention. Data loss is minimized or eliminated, thereby insuring that the user's data applications are not disturbed when moving from an IS-2000 (3G) coverage area to an IS-95-only (2G) area.

According to a first broad aspect, the invention provides in a CDMA communications system, a method for switching a 3G packet data call to a 2G circuit switched data call, the method comprising the steps of: identifying a mobile station that is exiting an area of 3G coverage and entering an area of 2G coverage; negotiating service options between the mobile and a base station controller; and switching from a 3G packet data service option to a 2G circuit switched data service option.

According to a second broad aspect, the invention provides in a CDMA communications system, a method for switching a 3G packet data call to a 2G packet data call, the

method comprising the steps of: identifying a mobile station that is exiting an area of 3G coverage and entering an area of 2G coverage; negotiating service options between the MS and the BSC; modifying the R-P interface; and switching from 3G high-speed packet data service option to a non-high-speed packet data service option.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of the specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings that illustrate embodiments of the invention,

Figure 1A and 1B are a block diagrams of two different CDMA communications systems;

Figure 2 is a diagram of an IS-95 protocol stack for a circuit switched data session;

Figure 3 is a diagram of an IS-2000 protocol stack for a packet data session;

Figure 4 is a diagram of the protocol stack used in the preferred embodiment of the invention;

Figure 5 is a diagram of the protocol stack used in alternative embodiment of the invention;

Figure 6A is a flowchart showing the execution of the preferred embodiment of the invention;

Figure 6B is a flowchart showing the reverse execution of the preferred embodiment of the invention; and

Figure 6C is a flowchart showing the execution of an alternative embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figure 1A, a preferred architecture of a mixed 2G and 3G CDMA mobile communication system **100** includes a plurality of MSCs (mobile switching centres) **101** (only one shown). Each MSC **101** is connected to a plurality of BSs (base stations) **103** (only one shown) via an A_1, A_2 and A_5 interfaces **111**. Each BS **103** comprises a BSC (base station controller) **104** and a plurality of BTSs (base station transceivers) **106,108** (only two shown). The BSC **104** has a cell/neighbor database **105** and a PCF (packet control function) **107**. The BTSs **106,108** communicate via over-the-air U_m interfaces **113,115** respectively with a plurality of MSs (mobile stations) **114** (only one shown). In this example, for convenience, BTS **106** is a non-high-speed data 2G base station providing IS-95 coverage in area **110** (via U_m interface **113**) and BTS **108** is a high-speed data 3G base station providing IS-2000 coverage in area **112** (via U_m interface **115**); the areas or cells covered by BTS **106** and BTS **108** are adjacent and separated by a coverage boundary **109**. However, in reality, the coverage areas may be mixed IS-95/IS2000 coverage areas or overlapping areas and still be within the scope of this invention. Each MSC **101** has a VLR (visitor location registry) **102** containing information regarding all MSs **114**. The VLR **102** may be internal or external to the MSC **101**. Each MS **114** comprises an MT2 (mobile terminal) **116** and TE2 (terminal equipment) **118** interconnected via an R_m (the interface between a TE2 and an MT2) interface **117**. The BSC

104 is connected via an R-P (PCF (packet control function) radio side to PDSN (packet data serving node) packet data side) interface **119** to a PDSN **120** that is connected to the Internet **128**. The MSC **101** is connected via an L-interface (IWF-serving MSC to BSC) **121** to an IWF (interworking function) **122** that is also connected to the Internet **128** via a QNC (Quick Network Connect or Fast Connect) link **127**. The IWF **122** has a plurality of modems **123** (only one shown) connected to the L-interface **121**. Alternatively, the IWF **122** can be connected to the BSC **104** (not shown). The MSC **101** is also connected to the PSTN (public switched telephone network) **124** via an A_1 interface **129**. A RAS (remote access server) **126** provides a connection between the PSTN **124** and the Internet **128**.

Referring to Figure 1B, an alternative architecture of a mixed 2G and 3G CDMA mobile communication system **130** includes a plurality of FWA (fixed wireless access), where an IWF is located at the BSC switches **132** (only one shown). Each FWA switch **132** is connected via link **134**, that may be, for example, ITU-T V5.2 or Bellcore TR-303, to a plurality of BSs **103** (only one shown). Each BS **103** comprises a BSC **104** and a plurality of BTSs **106,108** (only two shown). The BSC **104** has a cell/neighbor database **105** and a PCF **107**. The BTSs **106,108** communicate via over-the-air U_m interfaces **113,115** respectively with a plurality of MSs **114** (only one shown). In this example, for convenience, BTS **106** is a 2G base station providing IS-95 coverage in area **110** (via U_m interface **113**) and BTS **108** is a 3G base station providing IS-2000 coverage in area **112** (via U_m interface **115**); the areas or cells covered by BTS **106** and BTS **108** are adjacent and separated by a coverage boundary **109**. However, in reality, the coverage areas may be mixed IS-95/IS-2000 coverage areas or overlapping areas and still be within the scope of this

invention. Each MS **114** comprises a MT2 **116** and TE2 **118** that are interconnected via an R_m interface **117**. The BSC **104** is connected via an R-P interface **119** to a PDSN **120**. The BSC **104** is also connected via an IWF/BSC interface **136** to an IWF **122** that is connected to the internet via a QNC link **127**. The IWF **122** has a plurality of modems **123** (only one shown) connected to the IWF/BSC interface **136**. The FWA switch **132** is also connected to the PSTN **124**. A RAS **126** provides a connection between the PSTN **124** and the Internet **128**.

The most widespread method of providing Internet access in a CDMA cellular network is based on the IS-707 (Telecommunications Industry Association (TIA) interim standard title: "Data Services Options for Spread Spectrum Systems"), IS-95 (TIA interim standard title: "Mobile Station-Base Station Compatibility Standard for Wideband Spread Spectrum Cellular Systems") and IS-99 (TIA interim standard title: "Data Services Option Standard for Wideband Spread Spectrum Digital Cellular System") standards for a circuit-switched data (CSD) service option. These standards are incorporated by reference herein. This service provides the user with data and fax at rates up to 14.4 kbps. Specifically, CDMA supports data rates at 9.6kbs and 14.4kbs and Fax at the same rates. In the architecture shown in Figure 1A, the MSC **101** circuit switches data from the MS/BSC **114,104** to the IWF **122**. The IWF **122** is anchored at the MSC **101** or, alternatively, it may be anchored at the BSC **104** (not shown). In the IWF **122**, a modem **123** provides modulated data to the PSTN **124** through the MSC **101** for connection to the RAS **126**.

In the alternative architecture shown in Figure 1B, the FWA switch **132** switches data from the MS/BSC **114,104** to the PSTN **124**. The IWF **112** is anchored at the BSC **104**. Since

there is no modem in the MS **114** and the FWA switch **132** does not understand wireless data, the call is routed through the IWF **122** to be modulated/demodulated by the modems **123**. The BSC **104** appears as a normal trunk peripheral to the FWA switch **132**. Alternatively in the IWF **112** for a QNC/Fast Connect **127** Call, the data can be sent directly to the Internet **128** bypassing the modem **123** in the IWF **122**.

Referring to Figure 2, a protocol stack model for a 2G CDMA mobile communication system providing circuit switched data services in which a mobile user accesses the Internet via a remote access server **200** comprises a TE2 protocol stack **210**, an MT2 protocol stack **218**, a BS/MSC protocol stack **246**, an IWF protocol stack **256** and a RAS stack **290**. The protocol stack model for a 2G CDMA mobile communication system providing circuit switched data services in which a mobile user accesses the Internet via a remote access server **200** also comprises a relay layer **201**, a link layer **202**, a network layer **204**, a transport layer **206** and an application layer **208**. The TE2 protocol stack **210** comprises upper layer protocols **211**, IP **212**, PPP **213**, on the application layer **208** and RS-232 **214**. The MT2 protocol stack **218** comprises RS-232 **220**; an MT2 relay **222** and an application interface **224** on the application layer **208**; TCP (transport control protocol) **226** and ICMP (internet control message protocol) **228** on the transport layer **206**; IP (internet protocol) **230** on the network layer **204**; SNDCF (sub network-dependent convergence protocol) **232**, IPCP (internet protocol control protocol) **234**, LCP (link control protocol) **236** and PPP (point to point protocol) **238** on the link layer **202**; RLP (radio link protocol) **240** and IS-95-A (TIA interim standard for Mobile Station-Base Station Compatibility Standard for Wideband Cellular Systems) **242** over U_m **201**. The BS/MSC protocol stack **246** comprises IS-95-A **248**, RLP **250** and a relay

layer protocol **254** and relay layer **252** on the link layer **202**. The IWF protocol stack **256** comprises a relay layer protocol **258** on the relay layer 201; PPP **260**, LCP **262**, IPCP **264** and SNDCF **266** on the link layer **202**; IP **268** on the network layer **204**; ICMP **270** and TCP **272** on the transport layer **206**; a relay **276** and an application interface **278** on the application layer **208**; and terminating on a data or fax modem connection to the PSTN **280**. The RAS stack **290** comprises a PSTN data modem protocol **284** on the relay layer **201**, link layer **202**, network layer **204** and transport layer **206**; PPP **286** and IP **288** on the application layer **208**. The TE2 **210** communicates MT2 **218** via the R_m interface **117**. The MT2 **218** communicates with the BS/MSC protocol stack **246** via the U_m interface **113**. The BS/MSC communicates with the IWF **256** via the L-interface **121**. The IWF **122** communicates with the RAS **126** via the A_i interface **129**.

A mobile originated data only session can be made directly to the Internet. In this scenario, referring to Figure 1A, the MSC **101** circuit switches data from the MS/BSC **114/104** to the IWF **122**. Instead of the IWF **122** modulating the data through a modem **123** to go through the PSTN **124** to the RAS **126**, the IWF **122** allows direct connection via QNC **127** to the Internet **128**. This is a packet data call to the Internet **128** (no modems or PSTN connection). However, the path from the BSC **104** to the Internet **128** via the IWF **122** is circuit switched through the MSC **101**. This provides a pipe to the IWF **122** and also allows for mobility between BTSs **106**, BSCs **104** or MSCs **101** without disruption of the data session.

For the BSC **104**, the role in terms of power control, mobility and call setup remain the same as with voice. However the processing of the bearer path is significantly different. For voice, the BSC **104** receives PCM

(pulse code modulation) encoded voice from the MSC **101** and trans-codes the voice into a format to be transmitted over the air. The format is negotiated upon call setup and is referred to as the service option for the call. The popular service options in use today include the 13K service option which encodes/decodes voice at 14.4kbs to/from 64kbs PCM and EVRC (enhanced variable rate codec) that runs at 9.6kbs. With data, the BSC **104** and MS **114** use a service option to indicate that the call will be data or fax. However, the BSC **104** receives data from the IWF **122** via the MSC **101** (circuit switched). The data is not trans-coded though. Rather the BSC **104** runs a protocol called RLP (Radio Link Protocol) with the MS **114**. This layer 2 protocol uses retransmission schemes to reduce error rates and ensure the integrity of the data transferred over the air between the MS **114** and the BSC **104**. At the MS **114** the RLP frames are passed up the protocol stack once received. Similarly, the BSC **104** transmits data received from the MS **114** through a relay protocol such as, for example, ISLP (inter-system link protocol) to the IWF **122**.

Hence the MS **114** establishes an end to end connection with the IWF **122** using RLP between the MS **114** and BSC **104** and ISLP between the BSC **104** and IWF **122**. However, at higher levels, referring to Figures 1A and 2, the MS **114** and IWF **122** negotiate a TCP **226,272** /IP **230,268** /PPP **238,260** session for communication with the IWF **122**. With the connection of the terminal equipment (TE2 **118**, a PC for example) an end to end IP **212,288** /PPP **213,286** connection is negotiated between the TE2 **118** and the RAS **126**. For example, a PC dials-in to a terminal server such as a normal modem.

It is important to note that a modem is not used between the MS **114** and the IWF **122**. The actual modem connection is established between the IWF **122** and the RAS **126**

through the PSTN **124**. Advantageously, the lack of modem allows the MS **114** and the IWF **122** to establish a packet data connection of their own through a circuit connection on the MSC **101**. Hence the MS **114** can communicate directly to the Internet **128** via the IWF **122**. This service is known as QNC or Fast Connect. This is a packet data connection from the MS **114** to the Internet **128**. It just happens to be carried through the MSC **101** circuit connection to get to the IWF **112** and deal with mobility.

With the introduction of higher-speed traffic channels in IS-2000, a new high-speed packet data service option (IS-707-A-1.12) was defined which supports burst data rates of up to 153.6 kbps (in the initial release). Unlike the CSD service option, this service option was intended to support IP access directly. The protocol stack for this service option is shown in Figure 3.

Referring to Figure 3, a protocol stack model for a 3G CDMA mobile communication system offering high-speed packet data services **300** comprises a TE2 protocol stack **308**, an MT2 protocol stack **318**, a BS/PCF protocol stack **328** and a PDSN protocol stack **342**. The protocol stack model for a 3G CDMA mobile communication system **300** also comprises a relay layer **301**, a link layer **302**, a network layer **304** and an upper layer protocols layer **306**. The TE2 protocol stack **308** comprises upper layer protocols **310** on the upper layer protocol layer **306**, IP **312** on the network layer **304**, PPP **314** on the link layer **302** and R_m relay layer protocol **316** on the relay layer **301** over R_m **117**. The MT2 protocol stack **318** comprises R_m relay layer protocol **320** over R_m **117**, L_m link layer protocol **324** and airlink **326** on U_m **115**; and L2 relay **322** on the link layer **302**. The BS/PCF protocol stack **328** comprises airlink protocol **330**, L_m link layer protocol **332**,

A_{quater} network layer protocol **336**, A_{quater} link layer protocol **338** and physical layer protocol **340**; and L2 relay **334** on the link layer **302**. The PDSN protocol stack **342** comprises a physical layer protocol **344**, A_{quater} link layer protocol **346** and A_{quater} network layer protocol **348** on the relay layer **301**; PPP **350** on the link layer **302**; IP **352** on the network layer **304**; and upper layer protocols **354** on the upper layers **306**. The relay layer **301** of the TE2 protocol stack **308** communicates with the relay layer **301** of the MT2 protocol stack **318** via the R_m interface **117**. The relay layer **301** of the MT2 protocol stack **218** communicates with the relay layer **301** of the BS/PCF protocol stack **328** via the U_m interface **115**. The relay layer **301** of the BS/PCF protocol stack **328** communicates with the relay layer **301** of the PDSN protocol stack **342** via the R-P interface **119**.

In the 3G packet data configuration, the communication paths between the TE2 **118** and the network inter-working function (PDSN **120** in this case) is much more direct. As shown in the protocol stack (Figure 3), the protocol complexity on the terminal has become simpler. The terminal serves to exchange data with the TE2 **118** and transmit/receive it over the air. The Airlink **115** in this case is IS-2000 while the L_m link layer **324** is provided by RLP as with CSD. The RLP for packet data is changed from RLP-1 for CSD and RLP-3 for 3G to deal with the higher data rates. Another set of protocol stacks (as specified in IS-2001 titled: "Interoperability Specification for CDMA 2000 Access Network Interfaces") is used to transport data between the BSC/PCF **104,107** and the PDSN **120**.

In this configuration the PPP session on the TE2 **118** is established with the PDSN **120**. Hence PPP frames are in

essence directly exchanged. The BSC/PCF **104,107** and MS **114** serve as intermediate relays of the PPP frames.

Referring to Figure 4, a protocol stack model of the preferred embodiment of the invention **400** comprises a TE2 protocol stack **416**, an MT2 protocol stack **426**, a BS/PCF protocol stack **450** and a PDSN protocol stack **462**. The protocol stack model for a mixed 2G/3G CDMA mobile communication system **400** also comprises a relay layer **401**, a IS-707-A.4 link layer **402**, a IS-707-A.4 network layer **404**, a IS-707-A.4 transport layer **406**, and application layer **408**, a IS-707-A-1.12 PDSN link layer **410**, a IS-707-A-1.12 network layer **412** and an upper layer **414**. The TE2 protocol stack **416** comprises upper layer protocols **418** on the upper layer **414**, IP **420** on the IS-707-A-1.12 network layer **412**, PPP **422** on the IS-707-A-1.12 PDSN link layer **410** and RS-232 **424** on the application layer **408**, IS-707-A.4 transport layer **406**, IS-707-A.4 network layer **404**, IS-707-A.4 link layer **402** and relay layer **401**. The MT2 protocol stack **426** comprises RS-232 **428** on the application layer **408**, IS-707-A.4 transport layer **406**, IS-707-A.4 network layer **404**, IS-707-A.4 link layer **402** and relay layer **401**; relay **430** on the IS-707-A-1.12 PDSN link layer **410**; an application interface **432** on the application layer **408**, TCP **434** and ICMP **436** on the IS-707-A.4 transport layer **406**; IP **438** on the IS-707-A.4 network layer **404**; IPCP **440**, SNDCF **442** and PPP **444** on the IS-707-A.4 link layer **402**; RLP **446** and IS-95 **448** on the relay layer **401**. The BS/PCF protocol stack **450** comprises IS-95 **452**, RLP **454**, A_{quater} **458** and PHYS **460** on the relay layer **401** and relay **456** on the IS-707-A.4 link layer **402**. The PDSN protocol stack **462** comprises PHYS **464** and A_{quater} **466** on the relay layer **401**; PPP **468**, IPCP **470** and SNDCF **472** on the IS-707-A.4 link layer **402**; IP **474** on the IS-707-A.4 network layer; ICMP **476** and TCP **478** on the IS-707-A.4 transport layer; an application interface

480 on the application layer **408**; PPP **482** on the IS-707-A-1.12 PDSN link layer **410**, IP **484** on the IS-707-A-1.12 network layer **412**; and upper layer protocols on the upper layer **414**. The relay layer **401** of the TE2 protocol stack **418** communicates with the relay layer **401** of the MT2 protocol stack **426** via the R_m interface **117**. The relay layer **401** of the MT2 protocol stack **426** communicates with the relay layer **401** of the BS/PCF protocol stack **450** via the U_m interface **113**. The relay layer **410** of the BS/PCF protocol stack **450** communicates with the relay layer **401** of the PDSN protocol stack **462** via the R-P interface **119**.

Referring to Figure 5, a protocol stack model for an alternative embodiment of the invention **500** comprises a TE2 protocol stack **508**, an MT2 protocol stack **518**, a BS/MSC protocol stack **528** and a PDSN protocol stack **538**. The protocol stack model for a mixed 2G/3G CDMA mobile communication system **500** also comprises a relay layer **502**, a link layer **503**, a network layer **504** and an upper layer **506**. The TE2 protocol stack **508** comprises upper layer protocols **510** on the upper layer **506**, network layer protocols **512** on the network layer **504**, PPP **514** on the link layer **503** and EIA-232 **516** on the relay layer **502**. The MT2 protocol stack comprises EIA-232 **520**, RLP **524** and IS-95 **526** on the relay layer **502**; and L2 relay **522** on the link layer. The BS/MSC protocol stack comprises IS-95 **530**, RLP **532**, A_{quater} network layer protocol **336**, A_{quater} link layer protocol **338** and physical layer protocol **340** on the relay layer **502**. The PDSN protocol stack **538** comprises a physical layer protocol **344**, A_{quater} link layer protocol **346**, A_{quater} network layer protocol **348** on the relay layer **502**; PPP **542** on the link layer **503**, network layer protocols **544** on the network layer **504** and upper layer protocols **546** on the upper layers **506**. The relay layer **502** of the TE2 protocol stack **508** communicates with the

relay layer **502** of the MT2 protocol stack **518** via the R_m interface **117**. The relay layer **502** of the MT2 protocol stack **518** communicates with the relay layer **502** of the BS/MSC protocol stack via the U_m interface **113**. The relay layer **502** of the BS/MSC protocol stack communicates with the relay layer **540** of the PDSN protocol stack **538** via A_{quater} **119**.

The invention allows an MS **114** to traverse the boundary of 3G IS-2000 coverage without experiencing disruptions in the PPP layer, thus allowing continuity of the user's application. This is done through the following method that is summarized in the flow chart of Figure 6A. This method is applicable to the architecture shown in Figure 1A and 1B. The BSC **104** determines that the MS **114** is departing from the IS-2000 coverage area **112** (Step **602**). This is done using existing mechanisms used to trigger handoffs in the CDMA network. If the MS **114** is not leaving the IS-2000 coverage area **112** then IS-2000 coverage continues (Step **604**). As the MS **114** approaches the coverage boundary **109** it will, as part of normal IS-2000 soft handoff procedures, report the identity (PN (pseudorandom noise) offset) and pilot channel signal strength of adjacent cells in a Pilot Strength Measurement Message to the BTS **108**. Alternatively, the BSC **104** can determine via exiting mechanisms that the MS **114** is nearing the boundary. The BSC **104** receives this message from the BTS **108** and compares the reported PN offsets to the cell/neighbor database **105** to determine the possible candidate target cells for soft handoff. The cell/neighbor database **105** includes information as to whether the target cells can support the IS-2000 traffic channels (Step **606**). If one or more of the target cells can support IS-2000 traffic channels then continue with the standard handoff procedure (Step **608**). If none of the suitable target cells can support IS-2000 traffic channels, then the BSC **104** concludes that the

mobile is leaving the IS-2000 coverage area **112**, and that the BSC **140** must switch the call to an IS-95 traffic channel.

Alternatively, the BSC **104** need not know beforehand whether the target cell **110** can support IS-2000 traffic channels. The BSC **104**, as part of the soft handoff procedure, requests an IS-2000 traffic channel from the target cell **110**. The target cell **110** responds that it cannot provide an IS-2000 traffic channel either explicitly or implicitly (by using a message format that only applies to IS-95 traffic channels). In either case, the BSC **104** concludes that it must switch the call to an IS-95 traffic channel.

Since the call must be switched to an IS-95 traffic channel, and since the high-speed packet data service option is not supported on IS-95 traffic channels, the BSC **104** concludes that it must switch the call from the high-speed packet data service option to the CSD service option. This is performed using existing service negotiation or service option negotiation procedures, as described in the IS-95, IS-2000, and IS-707-A standards. The BSC **104** proposes to the MS **114** that the existing packet data service option be ended, and a new CSD service option be connected (Step **610**). If the MS **114** cannot accept the service option change (Step **611**) then no further action is taken by the BSC **104**. The coverage fades and the call is dropped and the work of step **615** is undone (Step **612**). If the MS **114** can accept the service option change, the BSC **104** instructs the MS **114** to release the existing IS-2000 physical channel(s) and replace them with IS-95 physical channel(s) (Step **613**). This latter step can be performed as part of the handoff procedure.

Assuming the MS **114** accepts the change of service option, it performs any required initialization of the RLP

446, PPP **444**, IP **438**, TCP **434**, and application interface **432** layers according to IS-707-A.4 without disturbing the R_m interface **117** relay layer **401** (Step **614**). In the 3G protocol stack model **300**, the TE2 PPP layer **314** rides on top of the R_m relay layer **316**. As long as this layer is not disturbed, there should be no impact to the user's PPP **314**, IP **312**, or upper-layer protocols **310**.

While the BSC **104** is in the process of commanding the MS **114** to switch from 3G service to 2G service, it signals to the PDSN **120** (via the R-P interface **119**) that it must alter the protocol stack used on the R-P interface **119** to carry the user's PPP frames (Step **615**). This requires new signalling messages on the R-P interface. For example, the BSC **104** sends the PDSN **120** an Incoming Call Request (ICRO) L2TP message with a new attribute value pair (AVP) indicating that the existing user session (referred to as a call in the L2TP standard) should be switched to the IS-707-A.4 protocol stack, while preserving the TE2 **118** to PDSN **120** PPP connection.

Alternatively, for networks employing the standardized IS-2001 A_{10} and A_{11} protocols on the R-P interface **119**, extensions to the A_{10} and A_{11} are used to provide this information. For example, the BSC/PCF **104/107** sends an A_{11} Registration Request message modified to include an information element to indicate that the existing user session should be switched to the IS-707-A.4 protocol stack, while preserving the TE2 **118** to PDSN **120** PPP connection.

Once this signalling transaction on the R-P interface **119** is completed, the BSC **104** switches the radio (U_m) interface relay layer **113**, which had previously been using the RLP-3 protocol (per IS-707-A-1.10), to the RLP-1

protocol (per IS-707-A.2) (Step **616**). The BSC **104** continues to relay the content of RLP frames to the PDSN **120** over the R-P interface **119**.

The PDSN **120** proceeds to initialize the IS-707-A.4 relay **401**, link **402**, network **404**, transport **406**, and application interface **408** layers according to IS-707-A.4. Once initialized, the PDSN **120** delivers the user PPP data destined for the TE2 **118** (the IS-707-A-1.12 link layer **410** data) to the IS-707-A.4 application interface layer's application **480**. User PPP data arriving from the TE2 **118** is delivered by the IS-707-A.4 application layer interface **480** in the PDSN **120** to the IS-707-A-1.12 link layer **402** (Step **618**). Note that there are essentially two link layers in operation at this point: the IS-707-A.4 link layer **410** between the Mobile Station's MT2 **116** and a virtual IWF in the PDSN **120**, and what was originally the IS-707-A-1.12 link layer **402** between PDSN **120** and the Mobile Station's TE2 **118**. The latter consists of a PPP connection, which from the point of view of the IS-707-A.4 service option is now considered application data. The switch to IS-95 coverage is complete (Step **620**).

Note that at this point, it is not possible to handoff the data session to another PDSN. If the user should be handed-off to another system that doesn't have connectivity to the existing PDSN **120**, the data session must be released.

Advantageously, this procedure can be performed in reverse when the MS **114** moves from a 2G coverage area **110** into a 3G coverage area **112**. This is done through the following method that is summarized in the flow chart of Figure 6B. The BSC **104** determines that the MS **114** is

departing from the current IS-95 coverage area **110** (Step **652**). If the MS **114** is not leaving the IS-95 coverage area **112** the IS-95 coverage continues (Step **654**). Otherwise, the BSC **104** determines it the new target cell is capable of IS-2000 operation (Step **656**). If none of the target cells can support IS-2000 traffic channels then continue with standard handoff method (Step **658**). The BSC **104** proposes to the MS **114** that the existing CSD service option be ended, and a new packet data service option be connected (Step **660**). If the MS **114** can't accept the service option change (Step **661**) then continue as a circuit switched data call (Step **662**). As well, the work in Step **665** is undone. Otherwise, the BSC **104** instructs the MS **114** to release the existing IS-95 channel(s) and replace them with IS-2000 channels (Step **663**). Otherwise, the BSC **104** indicates that the RLP **446**, RLP **444**, IP **438**, TCP **434**, and Application Interface 432 layers should be removed (Step **664**). Meanwhile, the BSC **104** signals the PDSN **120** (via the R-P interface **119**) that it must alter the protocol stack used on the R-P interface **119** to carry the user's PPP frames (Step **665**). Once the R-P interface **119** transaction is complete, the BSC **104** to relay the content of the RLP-3 frames to the PDSN **120** over the R-P interface **119** (Step **668**). The transition to IS-2000 coverage is complete (Step **670**). The protocol stack for this service option is shown in Figure 3.

At this point there is no restriction on inter-system handoff.

Alternatively, instead of switching to CSD, switch to non-high-speed packet data service option IS-707-A-5. The protocol stack is similar to high-speed packet data service option. The protocol stack for this service option is shown in Figure 5. This is done through the following method that

is summarized in the flow chart of Figure 6C. This method is similar to the preferred embodiment method of the flow chart shown in Figure 6A except for the following changes. In Step **610** a new 2G packet data option is proposed. Step **615** is not performed. In Step **614** RLP **446** is initialized without disturbing the R_m interface **117** relay layer. In Step **618** the PDSN **120** delivers the user PPP data destined for the TE2 **118** (the IS-707 link layer **542** data) to the BS/PCF **104,107**. The user PPP data arriving from the TE2 **118** is delivered by the PDSN **120** to the IS-707 BS/PCF **104/107** to link layer **542**.

Those skilled in the art should also appreciate that in some embodiments of the invention, all or part of the functionality previously described herein with respect to the invention may be implemented as pre-programmed hardware or firmware elements (not shown) such as application specific circuits, erasable programmable read-only memories or other similar components. Such pre-programmed hardware or firmware elements may reside, for example, in the BS **103**, the MS **114**, the MSC **101** or the PDSN **120**.

In other embodiments of the invention, all or part of the functionality previously described herein with respect to the invention may be implemented as software consisting of a series of instructions for execution by a computer system or multiple computer systems. Such computer systems may reside, for example, in the BS **103**, the MS **114**, the MSC **101** or the PDSN **120**.

The series of instructions could be stored on a medium that is readable directly by the computer system (such as a removable diskette, CR-ROM, ROM or fixed disk) or the instructions could be stored remotely but transmittable to

the computer system via a modem or other interface device connected to a network over a transmission medium.

While the preferred embodiment of the present invention has been described and illustrated, it will be apparent to persons skilled in the art that numerous modifications and variations are possible. The scope of the invention, therefore, is only to be limited by the claims appended hereto.